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(71) Applicant:  
HE HOLDINGS, INC. dba HUGHES  
ELECTRONICS  
Los Angeles, CA 90045-0066 (US)

(72) Inventors:  
• Caplin, Glenn N.  
Manhattan Beach, CA 90266 (US)

• Schultz, James W.  
El Sugundo, CA 90245 (US)  
• Santos, Romeo, jr.  
Los Angeles, CA 90066 (US)  
• York, Gary M.  
Gardena, CA 90249 (US)

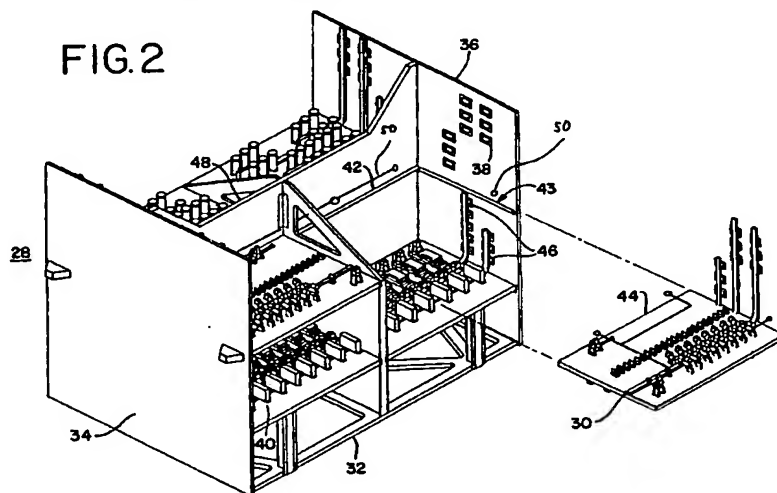
(74) Representative:  
Otten, Hajo, Dr.-Ing. et al  
Witte, Weller, Gahlert, Otten & Steil,  
Patentanwälte,  
Rotebühlstrasse 121  
70178 Stuttgart (DE)

### (54) Modular payload arrangement

(57) A modular spacecraft structure comprises a payload structure (28) having a first mechanical interface (42). Said first mechanical interface (42) is adapted to accept heat generating hardware (40). Further provided is at least one fixed panel (34, 36), having a sec-

ond mechanical interface (43). Said second mechanical interface (43) is adapted to accept said heat generating hardware (40).

FIG.2





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# EUROPEAN SEARCH REPORT

Application Number  
EP 96 12 0417

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US 4 324 375 A (O'NEILL) 13 April 1982	1,3	B64G1/10
Y	* column 1, line 53 - column 2, line 21 *	5,7-9	B64G1/64
A	* column 2, line 53 - column 6, line 5 *	4,6, 10-13	
Y	EP 0 647 559 A (MATRA MARCONI SPACE) 12 April 1995	5,7-9	
A	* column 3, line 34 - column 5, line 2; figures 2-9 *	1	
X	FR 2 597 829 A (ERNO RAUMFAHRTTECHNIK) 30 October 1987	1	
A	* page 3, line 11 - line 34 * * page 7, line 5 - page 8, line 20; figures 1,2 *	2-13	
A	WO 92 00223 A (STANDARD SPACE PLATFORMS CORPORATION) 9 January 1992	1	
	* page 12, line 12 - page 19, line 6; figures 1-6 *		
A	EP 0 238 840 A (ERNO RAUMFAHRTTECHNIK GMBH) 30 September 1987	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
	* page 3, line 10 - page 6, line 15; figures 1-4 *		B64G
A	ONGARO ET AL.: "a standardisation policy to support columbus payloads" ESA BULLETIN, no. 73, February 1993, pages 69-75, XP000387410 noordwijk, NE * the whole document *	1	
The present search report has been drawn up for all claims			
Place of search <b>THE HAGUE</b>		Date of completion of the search <b>18 September 1998</b>	Examiner <b>Rivero, C</b>
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>			

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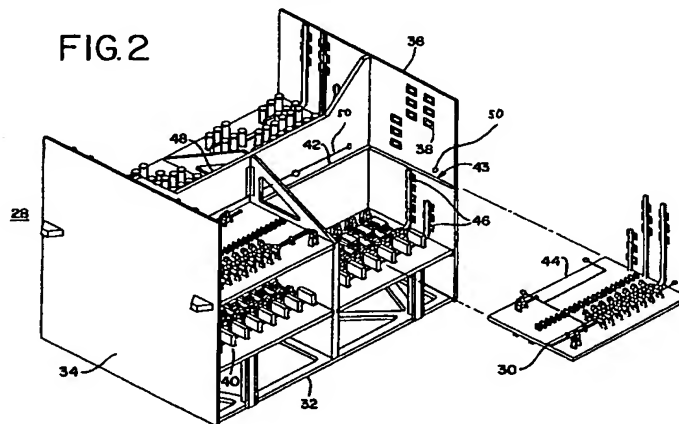
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ond mechanical interface (43). Said second mechanical interface (43) is adapted to accept said heat generating hardware (40).

FIG.2



EP 0 780 295 A2

## Description

### BACKGROUND OF THE INVENTION

In a spacecraft, such as a satellite for video data and telephonic communication purposes, a payload structure houses the communication equipment and other supporting equipment. The payload structures are typically custom-designed, depending on the type of mission for which the spacecraft is being deployed. Because these structures can be difficult to mass produce, they are typically hand-made to a great degree.

Traditional payload modules are designed with the bulk of the communications equipment mounted on the surface of the payload's radiator panels, the latter being used to dissipate unwanted heat energy from various heat generating hardware, including the communication modules. Because the communication modules are mounted on the surface of the radiator panels, the number of communication modules that can be used is limited by the size and number of panels.

Other known designs place the radiator panels closer to the center of the payload structure. This is an attempt to improve RF signal transmission by moving the communication modules closer to the satellite's antenna feeds which are located near the center of the payload structure. The result, however, is less interior space within the payload, leaving less room for antennas, propulsion systems and other equipment which are not loaded on the radiator panel side of the spacecraft.

For the above-described payload structures, as with most structures that house communication equipment and other hardware, there is a premium on maximum space utilization. This is especially true with regard to spacecraft payload structures and hardware, where much space is taken up by propulsion systems, power systems and other non-communication equipment.

Accordingly, there is a need for a payload structure that better utilizes space within the structure to house communications equipment. Additionally, there is a need for a payload structure that minimizes the need for custom design, thereby allowing for improved testing and rapid production and buildup of payload structures.

### SUMMARY OF THE INVENTION

The present invention achieves the foregoing benefits, along with other features and advantages, by providing a modular payload structure with standardized electrical and mechanical interfaces. The modular arrangement of the present invention may also have fixed panels that have standard thermal and mechanical interfaces, allowing communication modules and other heat generating hardware to "plug in" directly to the payload structure. The fixed panels may be radiator panels from which excess thermal energy may be rejected. In the case of high thermo-energy dissipating modules, such as high power amplifiers or output multiplexers,

heat pipes are placed in thermal communication with the modules and move energy from the modules to the radiator panel. Heat pipes may also be placed in thermal communication with other heat generating hardware.

The modular arrangement of the present invention also allows heat generating hardware to be positioned in the volume of the payload structure. Accordingly, more communication equipment and other hardware may be placed within the payload structure, making better use of the interior of the satellite. Placing communication modules within the volume of the spacecraft has other benefits such as moving the units closer to the antenna feeds. Because there is less distance for microwave signals to travel, output loss is minimized and energy efficiency is increased.

Also, the present invention provides for basic functional elements, such as the thermal, electrical, and mechanical interfaces on the modules, to be standardized. Complete payloads may be configured from the plug-in modules, thereby radically reducing the time required to design the payload. Other benefits of the present invention's modular arrangement include allowing for pre-design and pre-build production at a higher level. Also, each module operates separately from other modules, therefore, individuals assembling the modules can build payload structures at a faster rate through greater parallel production. When combined with a deployable radiator, the modular arrangement of the present invention allows for a larger mounted antenna for receiving and transmitting signals, which consequently provides increased gain and cross-polarization performance, and out of coverage suppression. Additionally, the modularity of the present invention allows units to be grouped by function. This is beneficial and creates a better testing environment because each module may be tested separately as the structure is built.

The invention, together with further features and attendant advantages, will be best understood by reference to the following detailed description, taken in conjunction with the accompanying drawing.

### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a spacecraft or satellite capable of utilizing the present invention.

Figure 2 is an illustration of a modular payload structure and a "plug-in" module, according to a preferred embodiment of the invention.

### DETAILED DESCRIPTION OF THE INVENTION

A spacecraft or satellite 10 capable of utilizing the present invention is shown in Figure 1. The satellite 10 has a spacecraft body 12 which includes a lower bus module or platform 14 and an upper payload structure 16. Attached to the aft end of the lower bus module 14 are a plurality of engines. These engines include a cen-

trally positioned liquid orbital thruster (not shown), four chemical propulsion engines 24 located at the corners of the bus module 14 and two pairs of xenon ion propulsion engines 26 (one pair shown). Lower bus module 14 contains fuel tanks (not shown) and various power and control modules that operate the engines and power the payload module 16. Bus module 14 further includes a pair of solar panels 18 that convert sunlight into electricity. The electricity is sent to batteries (not shown) located on the bus module 14. Bus module 14 also has a pair of antennae 20, which receive signals from an earth ground station. The antennae 20 reflect the received signals into reflectors 22, which in turn, reflect the signals into receivers (not shown). The antennae 20 are used to control the satellite 10 and to send signals to the ground station.

Payload structure 16 is attached to the bus module 14 and contains a variety of electronic equipment which may contain a number of sensors (not shown). The electronic equipment processes information gathered by the sensors and sends the processed information back to the ground station via antennae 20. The gathered information may concern for example, communications, weather observation, and navigational information.

Figure 2 is an illustration of a modular payload structure 28, according to a preferred embodiment of the invention. The payload structure 28 is the structural part of a satellite which carries the communications payload. The payload consists of plug-in modules 30 which have mechanical, electrical and thermal interfaces.

For reference purposes herein, the bottom of the payload structure 28, which is substantially rectangular in shape, on which a panel may be placed, shall be referred to as a base 32. The base 32 will be adapted to accept removable panels on at least two of its sides. Also, the structure that the panels are affixed to shall be referred to herein as the mid-section piece 48. The payload structure 28 has fixed radiator panels 34, 36 on opposite ends thereof. The fixed radiator panel 36 has a standard thermal interface 38 which provides for the dissipation of heat from heat generating hardware. Higher thermo-energy dissipating units require a means of dissipating waste heat to allow adequate operating temperatures. Higher thermo-energy dissipating units include high power amplifiers 40. Because the two types of high power amplifiers, traveling wave tube and solid state, are both thermally sensitive, the space savings provided by the modular arrangement of the present invention offers greater capacity for carrying these types of modules.

The payload structure 28 and the fixed radiator panel 36, have mechanical interfaces 42, 43 respectively, both of which are adapted to accept a standardized plug-in module. Plug-in module 30 rests on an auxiliary shelf 44. The plug-in module 30 may be a solid-state high power amplifier 40, or another type of known communication module. For these and other

high thermo-energy dissipating units, heat pipes 46 run from the plug-in module 30 and connect to the standard thermal interface 38 of the fixed radiator panel 36. Unless otherwise noted, other fixed radiator panels not herein shown are identical to those described herein. The present invention, though, does not preclude mounting equipment, either dissipating or non-dissipating, to the fixed radiator. Optionally, standard electrical interfaces 50 are harnessed along the center panel, or mid-section piece, and fixed radiators. The electrical interfaces 50 provide standard electrical power to telemetry and command interfaces in a manner analogous to a computer backplane bus. Taken together, the standard electrical, thermal and mechanical interfaces allow a modularity of payload elements. This modularity standardization of elements, pre-build, and design independent of other elements, and parallel manufacturing, none of which were allowed under the prior art.

It is therefore intended that the foregoing detailed description be regarded as illustrative rather than limiting, and that it be understood that it is the following claims, including all equivalents, which are intended to define the scope of the invention.

## Claims

1. A modular spacecraft structure, comprising:

a payload structure (28) having a first mechanical interface (42), said first mechanical interface (42) being adapted to accept heat generating hardware (40); and  
at least one fixed panel (34, 36), having a second mechanical interface (43), said second mechanical interface (43) being adapted to accept said heat generating hardware (40).

2. The modular spacecraft structure of claim 1, characterized in that said at least one fixed panel (34, 36) is a radiator.
3. The modular spacecraft structure of claim 1 or 2, characterized in that said heat generating hardware (40) is an amplifier.
4. The modular spacecraft structure of any of claims 1 - 3, characterized in that said heat generating hardware (40) is an output multiplexer.
5. The modular spacecraft structure of any of claims 1 - 4, characterized in that said heat generating hardware (40) is mounted on a shelf (44).
6. The modular spacecraft structure of claim 5, characterized in that said heat generating hardware (40) is substantially mounted within said payload structure (28) such that said shelf (44) extends away from said at least one fixed panel (34, 36).

7. The modular spacecraft structure of any of claims 1  
- 6, characterized in that said at least one fixed  
panel (34, 36) has a thermal interface (38).
8. The modular spacecraft structure of claim 7, char- 5  
acterized in that said thermal interface (38) of said  
at least one fixed panel (34, 36) is in thermal com-  
munication with a heat pipe (46).
9. The modular spacecraft structure of any of claims 1 10  
- 8, characterized in that said payload structure (28)  
has at least one electrical interface (50).
10. The modular spacecraft structure of any of claims 1  
- 9, characterized in that the payload structure (28) 15  
comprises a base (32), a first fixed panel (36) con-  
nected to a first side of said base (32), a second  
fixed panel (34) connected to a second side of said  
base (32) opposite said first fixed panel (36), and a  
mid-section piece (48) that connects to each of said 20  
base (32), said first fixed panel (36), and said sec-  
ond fixed panel (34), said mid-section piece (48)  
having said first mechanical interface (42) and said  
first fixed panel (36) having said second mechanical  
interface (33). 25
11. The modular spacecraft structure of claim 10, char-  
acterized in that said first fixed panel (36) has an  
electrical interface (50). 30
12. The modular spacecraft structure of claim 10 or 11,  
characterized in that said second fixed panel (34)  
has an electrical interface (50).
13. The modular spacecraft structure of any of claims 35  
10 - 12, characterized in that said mid-section piece  
(48) has an electrical interface (50).

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